

INTEGRAL ONE-WAY OVERRUN
CLUTCH WITH EPICYCLE GEAR SYSTEM

BACKGROUND OF THE INVENTION

[0001] The present invention relates to starter motors used to crank internal combustion engines. More particularly, the present invention relates to a starter motor which integrates the epicycle gear train and the one-way roller clutch into an axially compact unit.

[0002] Internal combustion engines conventionally use electric starter motors for cranking. Electric starter motors became popular in the late 1900's and early 1910's and incorporated a one-way clutch fitted to the end of the armature shaft of the starter. The one-way clutch is used during engine cranking to transmit torque and motion from the electrical motor to the output shaft and pinion and to the ring gear on the engine crankshaft. By only operating in a single direction, the clutch prevents the electric motor from being rotated too fast when driven by the engine after it has been successfully started. Typically the one-way clutch is in the form of a roller clutch that provides extra protection when a large load is transmitted from the engine to the starter by any means. The motor armature shaft is connected directly with the output shaft via the one-way clutch

[0003] As engine size and cylinder compression increased with advances in engine technology, an epicycle or planetary gear train was added to the starter motor arrangement to increase torque. According to known design, the epicycle gear train is separate from the one-way roller clutch assembly. By having two separate assemblies

the overall length of the starter is inherently long, thus creating engine compartment packaging problems. In addition, the greater length of the starter, which is a direct result of the arrangement of the two separate assemblies, results in vibration and fatigue failures.

SUMMARY OF THE INVENTION

[0004] The present invention provides an integral one-way roller clutch and epicycle gear train unit that overcomes the problems and limitations of known starter motors. Briefly, the integrated unit includes an integrated gear support/clutch barrel which, on one side, houses the roller and spring elements of the clutch and, on the other side, supports the planetary gears of the epicycle gear assembly.

[0005] This configuration offers several advantages over known starter motors. The integrated unit of the present invention provides for a shorter starter motor size, thus allowing for a superior packaging arrangement in the engine compartment. The present invention also is simpler than known starter motors in that it has fewer parts, thus saving material cost and reducing the tolerance stack-up from the normal variation of parts. In addition, the starter motor of the present invention demonstrates improved noise, vibration and harshness characteristics.

[0006] Further scope of applicability of the present invention will become apparent from the following detailed description, claims, and drawings. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present invention will become more fully understood from the detailed description given here below, the appended claims, and the accompanying drawings in which:

[0008] FIG. 1 is a longitudinal sectional view of a portion of a starter motor illustrating the epicycle gear train and the one-way roller clutch as being two separate assemblies as is known in the art;

[0009] FIG. 2 is a longitudinal sectional view of the starter motor of the present invention illustrated in the disengaged position;

[0010] FIG. 3 is an exploded perspective view of certain elements of the starter motor illustrated in Figure 2 which illustrates the relationship of the integral epicycle gear train and one-way roller clutch; and

[0011] FIG. 4 is a longitudinal sectional view of the starter motor of the present invention similar to the view of Figure 2 but illustrating the motor in the engaged position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] The following description of the preferred embodiment of the present invention provides an example of the present invention. The embodiment discussed herein is merely exemplary in nature and is not intended to limit the scope of the invention in any manner. Rather, the description of the preferred embodiment serves to enable a person of ordinary skill in the relevant art to make and use the present invention.

[0013] Figure 1 illustrates a longitudinal sectional view of a portion of a known starter motor, generally illustrated as 10. The starter motor 10 illustrates the epicycle gear train and the one-way roller clutch as being two separate assemblies as is known in the art. The starter motor 10 includes a motor housing 12 having a known configuration. Internally the starter motor 10 includes an armature shaft, the end of which is shown as shaft drive end 14, and an output shaft 16. The drive end 14 has a sun gear 18 formed thereon. The drive end 14 terminates at a bearing surface 20.

[0014] The output shaft 16 includes an end 22. Defined within the end 22 of the output shaft 16 is a bearing pocket 24. A sleeve bearing 26 is disposed within the bearing pocket 24. A thrust ball 28 is also fitted within the pocket 24. The bearing journal surface 20 is rotatably mounted within the sleeve bearing 26.

[0015] A plurality of planetary gear shafts are fitted to the end 22 of the output shaft 16, of which a single planetary gear shaft 30 is illustrated according to the sectional view of Figure 1. A like plurality of planetary gears are rotatably mounted on the planetary gear shafts, of which planetary gears 32, 32' are illustrated with the planetary gear 32' being fitted to the planetary gear shaft 30. The planetary gears are operatively mounted within a stationary gear 34 which is fixedly mounted within the starter motor housing 12. The operation of the sun, planetary, and stationary gears is known in the art.

[0016] A one-way clutch assembly, generally illustrated as 36, is illustrated relative to the epicycle gear train. The one-way clutch assembly 36 includes a clutch barrel 38 and a carrier shaft 40. A clutch roller cavity 42 is defined between the inner wall of the clutch barrel 38 and the outer wall of the carrier shaft 40. Within the clutch

roller cavity 42 are disposed a plurality of clutch rollers, of which one, clutch roller 44, is illustrated, and a like plurality of springs (not illustrated). The rollers are movable between a slipping position and a working position depending on the relative rotational speeds of the clutch barrel 38 and the carrier shaft 40 as is known in the art. The biasing action of the springs acts to maneuver the rollers to their locked (working) positions, as is also known in the art.

[0017] As may be seen by reference to Figure 1, the epicycle gear train and the one-way clutch assembly are spaced apart according to known configurations. The present invention, described hereinafter and illustrated in Figures 2 through 4, overcomes the disadvantages of this traditional arrangement by providing an integrated epicycle gear train/one-way clutch assembly.

[0018] Figure 2 is a longitudinal sectional view of a starter motor, generally illustrated as 100, according to the present invention. The starter motor 100 is shown in its disengaged position in this figure.

[0019] The starter motor 100 includes a housing 102. The housing 102 is comprised of a motor cover 104 removably attached to a starter housing 106. The motor cover 104 includes a closed end 108. Internally, the starter motor 100 includes a motor portion, generally illustrated as 110, an epicycle gear train/one-way roller clutch assembly, generally illustrated as 112, and a solenoid assembly, generally illustrated as 114.

[0020] The motor portion 110 includes an armature 116 having an armature shaft 118 which itself includes a first end 120 and a second end 122. The first end 120 of the armature shaft 118 is rotatably mounted within a sleeve bearing 124 that is

mounted in the closed end 108 of the motor cover 104. The motor portion 110 further includes armature windings 126 and a commutator 128 formed on the armature shaft 118 as is known in the art. The motor portion 110 also includes a plurality of magnets 130 fixed to the inner wall of the motor cover 104 and brush assemblies 132, 132' mounted to a support plate 134. The support plate 134 is fixedly mounted to the inner wall of the motor cover 104.

[0021] The second end 122 of the armature shaft 118 terminates in and is thus part of the epicycle gear train/one-way roller clutch assembly 112. The assembly 112 includes an integrated gear support/clutch barrel 136 having a gear side 138 and a clutch side 140. A plurality of planetary gear shafts are fitted to the gear side 138 of the integrated gear support/clutch barrel 136, of which a single planetary gear shaft 142 is illustrated according to the sectional view of Figure 2. Similarly, Figure 3, which shows an exploded perspective view of the operative epicycle gear train/one-way roller clutch assembly 112 including the integrated gear support/clutch barrel 136, illustrates additional planetary gear shafts 142', 142".

[0022] A like plurality of planetary gears are rotatably mounted on the planetary gear shafts, of which planetary gears 144, 144' are illustrated in Figure 2 with the planetary gear 144' being fitted to the planetary gear shaft 142. The planetary gears 144, 144' are also seen in Figure 3, which shows an additional planetary gear 144". The planetary gears are operatively mounted within a stationary gear 146 which is fixedly mounted within the starter motor housing 102. The integrated gear support/clutch barrel 136 is operatively mated to the stationary gear 146 by a support ring 147. The support ring 147 is fixedly attached to the stationary gear 146. A

support wall 149 is partially defined in the starter housing 106 against which the support ring 147 partially rests. The clutch barrel 136 is freely rotatable within the support ring 147.

[0023] The second end 122 of the armature shaft includes a sun gear 148 and a bearing surface 150 that is rotatably mounted within a sleeve bearing 152 that is fixedly and centrally mounted within an aperture defined in the end of the integrated gear support/clutch barrel 136. A thrust ball 151 is also fitted within the aperture defined in the end of the integrated gear support/clutch barrel 136. The operation of the sun, planetary, and stationary gears is consistent with known operation.

[0024] The epicycle gear train/one-way roller clutch assembly 112 further includes an output shaft 154. The output shaft 154 includes a race 156. A clutch roller housing 158 is defined between the inner wall of the clutch barrel 136 and the race 156. Within the clutch roller housing 158 is disposed a plurality of clutch rollers, of which two clutch rollers 160, 160' are shown in Figure 3. A like number of springs are provided for biasing the clutch rollers into their locked or working positions as is known in the art. Some of the springs are shown generally in Figure 2, while a pair of springs 162, 162' are more clearly seen in Figure 3.

[0025] The output shaft 154, which is also part of the clutch assembly 112, includes a series of parallel external helical splines 164 which are cut into the shaft 154. The helical splines 164 are seen sectionally in Figure 2 and perspective in Figure 3. The helical splines 164 mesh with a like number of internal helical splines 166 formed in the inner wall of an input end 168 of a carrier shaft 170, shown sectionally in Figure 2. The carrier shaft 170 also includes an output end 172 which is

mated via splines to a pinion gear 174 which is selectively matable with the ring gear of the internal combustion engine crankshaft (not shown) as will be described below. The output end 172 of the carrier shaft 170 is rotatably mounted within the clutch housing 106 by a bearing assembly 175.

[0026] The solenoid assembly 114 is of the open frame or "D" frame configuration. The assembly 114 includes a solenoid plunger 176 which selectively reciprocates with and lends support to the carrier shaft 170 in a known manner. A solenoid coil and bobbin assembly 178 is mounted in a coil frame 180. The frame 180 is fixedly mounted within the starter housing 106.

[0027] The solenoid assembly 114 is shown in Figure 2 in its open position wherein the motor 100 is disengaged and is in its resting configuration. In this position no power is directed to the motor 100.

[0028] Figure 4 illustrates the motor 100 in its engaged position in which the solenoid coil 178 has been energized via the ignition/starter switch (not shown), thus causing the solenoid plunger 176 to be drawn into the solenoid coil 178 against the force of a return spring 177. This position effects operative engagement of the pinion gear 174 with the ring gear (not shown). Engagement of the pinion gear 174 with the ring gear is assisted by a meshing spring 182 which is pre-loaded and provides a high pushing force to engage the pinion gear 174 with the ring gear. Electrical power is also sent to the motor portion 110, thus effecting rotation of the armature shaft 118. The shaft 118 drives the integrated gear support/clutch barrel 136 via the sun gear 148 and the planetary gears 144. The integrated gear support/barrel 136 drives the race 156 because of the friction that results between the integrated gear support/clutch

barrel 136, the clutch rollers 160, 160' ..., and the race 156. The output shaft 154 effects rotation of the pinion gear 174 via the carrier shaft 170.

[0029] Once the engine starts running, the revolutions of the race 156 exceed the revolutions of the integrated gear support/clutch barrel 136, and the rollers 160, 160' ... are returned to their pre-engagement positions as is known in the art. This causes the epicycle gear train/one-way roller clutch assembly 112 to slip, thus leading to the breaking of the connection between the pinion gear 174 and the armature shaft 118. By breaking this rotational connection the armature shaft 118 is prevented from being rotated too fast, thus avoiding being damaged. The pinion gear 174 remains meshed with the ring gear as long as the solenoid coil 178 is energized. The solenoid plunger 176, the carrier shaft 170, and the pinion gear 174 are all returned to their initial positions by the return spring 177 once the solenoid coil 178 is de-energized.

[0030] The foregoing discussion discloses and describes an exemplary embodiment of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims that various changes, modifications and variations can be made therein without departing from the true spirit and fair scope of the invention as defined by the following claims.